A High-Accuracy Crossover Equation of State for Carbon Dioxide

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Prior research has shown that the asymptotic singular critical behavior of the thermodynamic properties can be described in terms of scaling laws with universal critical exponents and scaling functions. Crossover equations of state, which incorporate the scaling laws asymptotically close to the critical point and are transformed into the regular classical expansion far away from the critical point, have been developed by Sengers and co-workers and by Kiselev *et al.* The principal idea of this approach consists in the renormalization of the temperature and the density in such a way that in the asymptotic critical region they become non-analytic scaling functions of the dimensionless distance to the critical point. In the past, crossover equations of state have been developed by "re-scaling" existing analytical equations, thereby producing hybrid models.

In this part of our research we have combined Kiselev's method with our selection algorithm equation of state structure optimization program to develop a very high accuracy, wide range equation of state for carbon dioxide. The unique feature of this equation is that its functional form was developed with the crossover mathematical "machinery" in place. This new equation of state has a modified BWR form,

$$\frac{A^r(\rho,T)}{RT} \equiv \frac{A(\rho,T) - A^{ig}(\rho,T)}{RT} = \sum_j a_j \tau^{s_j} \eta^{r_j} (e^{-\alpha_j \eta^{k_j}} - \alpha_j \delta_{r_j,0})$$

However, unlike previous equations developed by this method, this new equation has theoretically correct behavior near the critical point.

In this presentation we will discuss the development of the new equation of state and present comparisons with the current international standard developed by Span and Wagner.